Spring 2004

Physics 137B Section 1: Problem Set #9
Due: 5PM Friday April 23 in 2^{nd} floor LeConte-Birge Cross-Over

Suggested Reading for this Week:

- B& J Sections 13.1 - 13.4

Homework Problems:

1. (from Griffiths Problem 11.2) We saw in class that the general solution to the Schrodinger Equation for a particle of given initial momentum $p = \hbar k\hat{z}$ scattering off a potential $V(r)$ is

$$\psi(r,\theta) = A\left\{e^{ikz} + f(\theta)\frac{e^{ikr}}{r}\right\}$$

for large r. Construct the analogs to this equation for one-dimensional and two-dimensional scattering.

2. Using the definition of the cross section (B& J equation 13.1) and B& J Figure 13.6, prove B& J equations 13.87, 13.88, 13.89 and 13.90.

3. In class we saw that the wave function for scattering off a potential $V(r)$ can be expressed at large r in the form

$$\psi(r,\theta) = A\Sigma_{\ell=0}^{\infty}\left[i^{\ell}(2\ell+1)J_{\ell}(kr) + \sqrt{\frac{2\ell+1}{4\pi}}C_{\ell}h_{\ell}^{(}1)(Kr)\right]$$

and that for scattering off a hard sphere of radius a

$$C_{\ell} = -i^{\ell}\sqrt{4\pi(2\ell+1)}\frac{j_{e}ll(ka)}{h_{\ell}^{1}(ka)}$$

(see Griffiths pages 360-361)

(a) The radius R of a nucleus can be expressed as

$$R = r_0 A^{1/3}$$

where $R_0 = 1.1 \times 10^{-15}$ m and A is the mass number of the nucleus. Suppose a neutron scatters from a Gold nucleus. For what range of neutron momenta would you expect s-wave scattering to dominate?

(b) Suppose our nucleus has a kinetic energy of 1 MeV/c. What is the scattering cross section is you assume only s-wave scattering is important?

(c) What is the size of the p-wave ($\ell = 1$) term relative to ths s-wave term calculated above?

4. (taken from Liboff Problem 14.2) The scattering amplitude for a certain interaction is given by

$$f(\theta) = \frac{1}{k}\left(e^{ika}\sin ka + 3ie^{2ika}\cos\theta\right)$$

where a is the range of the potential and k is the wavenumber of the incident particle

(a) What is the s-wave differential cross section for this interaction?

(b) Suppose the above scattering amplitude is appropriate to neutrons incident on a species of nuclear target. Let a beam of 1.3 eV energy neutrons with current 10^{14} cm^{-2}s^{-1} be incident on this target. What number of neutrons per second are scattered out of the beam into $4\pi \times 10^{-3}$ sterradian about the forward direction? Take a to be 2×10^{-15} m.